Community-Based Solution for a Community Spread Requires Incentive-Compatibility Considerations

Frank Lorne[1], A.C. Lai, Sairam Katla, Krish Kale, Daniel Bocanegra Diaz

[1]*Corresponding author, Professor of Management, Email: florne@nyit.edu*
All authors are affiliated with the New York Institute of Technology-Vancouver, Canada

ABSTRACT: The war on coronavirus is being fought on many fronts. Unquestionably, the battle is in the ICU rooms, but nonpharmaceutical interventions (NPIs) are equally important. Humans can win a battle but lose the war with the virus. If an increase in asymmetric information in human interactions is the social consequence of a spreading virus, that information problem has to be directly addressed. The challenge is more than a task in science. It is also a socio-economic institutional challenge. Health systems of the world, while largely adopting a TTT (Testing, Tracing, Treatment) procedure in managing the virus, has not sufficiently addressed to community spreads in designing mechanisms that can signal suspects and hotspots effectively. The need for examining the system outside the healthcare structure is essential once we understand the traveling journey of a virus. Contact tracing, while direct in identifying suspects of infected individuals, may not be effective even with technology such as AI embedded. Aside from privacy issues, digital contact tracing entails human execution that is a voluntary decision in a free society. There is no assurance that the public will necessarily cooperate. This paper articulates a reason for addressing community-based solutions that are outside the normal health system management. We argue that for a community-based solution to be effective, incentive-compatibility must be considered. Our paper proposes a solution that entails the least privacy intrusion.

KEYWORDS: Nonpharmaceutical Interventions (NPIs), Contact Tracing, Community-based Solutions

Introduction

Human survival requires interactions in communities as well as across communities. Interactions can be social, economic, religious, and psychological, as people like to mingle. Isolation can be a temporary condition, but never a sustainable lifestyle for human survival. In this paper, we illustrate a need and a suggested community-based solution beyond medical remedies (i.e. NPIs) for combating community infectious virus spread. The socio-economic challenge is caused by an exponential spread with carrier of the virus being asymptomatic, i.e. without symptoms. Thus, in daily human interactions, people face what economists have called an "asymmetric information" problem in that one has no way of knowing the possibilities of being infected while interacting with strangers.

Solutions for mitigating asymmetric information problems usually entail screening, testing, signaling (Spence 2002; Connelly et.al. 2011; Lewis 2011; Hoppe and Schmitz 2015). Many of these economic concepts have applications for nonpharmaceutical interventions (NPIs). Forecasting for COVID-19, a preliminary SIR model suggested that signaling (identifying suspects) can be more important than testing (clinical proofs) (Chari, Kirpalani, Phelan 2020). The study simulated results, showing that a policy allowing discriminate isolation of those receiving "signal" and testing positive has the highest welfare gain estimated compared to other policies. This, as well as other studies, shows that there are different ways to address to the information problem caused by a spreading virus. Unless the fundamental issue of virus-caused asymmetric information problem is solved, we are not prepared to handle the next pandemic (Desmond-Hellmann 2020).

Community spread is no small matter, especially if it is exponential. Epidemiology models of COVID-19 can be many. Studying the problem after the facts, however, cannot provide effective guidance on preventive measures for a spreading pandemic. Prioritizing the needs to develop early warnings of a contagious virus before an outbreak can reduce economic impacts from subsequent lockdowns. At a broader level of community, i.e. for a country, more stringent guidelines for traveling could have been developed before the countries of the world shut their doors to 'foreigners" as the only pragmatic way to deal with the spread (Salcedo et.al. 2020). It is sarcastic to note the article commenting that "the coronavirus pandemic is, [as] a negative byproduct of our hyper-connected world,..brought about a nearly complete halt of global travel and tourism". Unfortunately, a virus does not carry a passport. Policies based on passport or ethnicity may not reduce the spread rate; as undetected leaks, however, small the number, to begin with, would spread exponentially. When it spreads exponentially, the number will necessarily be large. A country may contain a community spread temporarily, but when the border is reopened, travelers could bring the virus back in.

The importance of mitigation rather than containment has been addressed in various opinion pieces, e.g. Migration Policy Institute (Banulescu-Bogdan et.al. 2020), calling the closing of border a "blunt tool"; and yet, there are also proposals for establishing more (not less) stringent intranational lines (boundaries) based on real estate, (JLL 2020). We are seeing that an anti-foreigner sentiment has been glooming in many communities in various countries for some time now. Thus, action must be implemented starting with a community, perhaps before mitigation and containment are implemented, as latter measures may be deemed too late.

To persuade a community to consider adopting mitigation methods could be ineffective unless such practices are being embraced by a threshold population. This is difficult to be done voluntarily, as individual self-interest may not coincide with a common social goal. Voluntary participation requires an incentive-compatible design at a community level beyond the strategy of Testing, Tracing, and Treatment (TTT). The acronym has been used in numerous discussions in USA with different people referring to similar procedural steps but sometimes with a slightly different acronym or a different interpretation for the Ts. Regardless, procedural steps are usually executed in the health systems of a country (or a state) rather than voluntary community participation. Judging from a surge in positivity rate (confirmed positive case divided by the number of tests) in many states and specific counties, the strategy does not appear to be effective. Yet, reopening of an economy is a necessity, as people's lives need to return to some type of normalcy.

Mobility must be addressed as Countries are reopening

At this juncture where countries are gradually reopening, the question on how mobility could impact the spread of the virus and also the recovery is indeed very important. Figure 1 below provides a snapshot of the situation for different countries taken on May 28, 2020, which asks the question of reopening of economies based on two metrics: mobility index and the disease recovery rate. The idea is that economies are more likely to reopen, if the recovery rate is high. The proposition is that while there are 4 types of country classification, the general pattern seems to suggest a positive relationship between mobility and recovery.

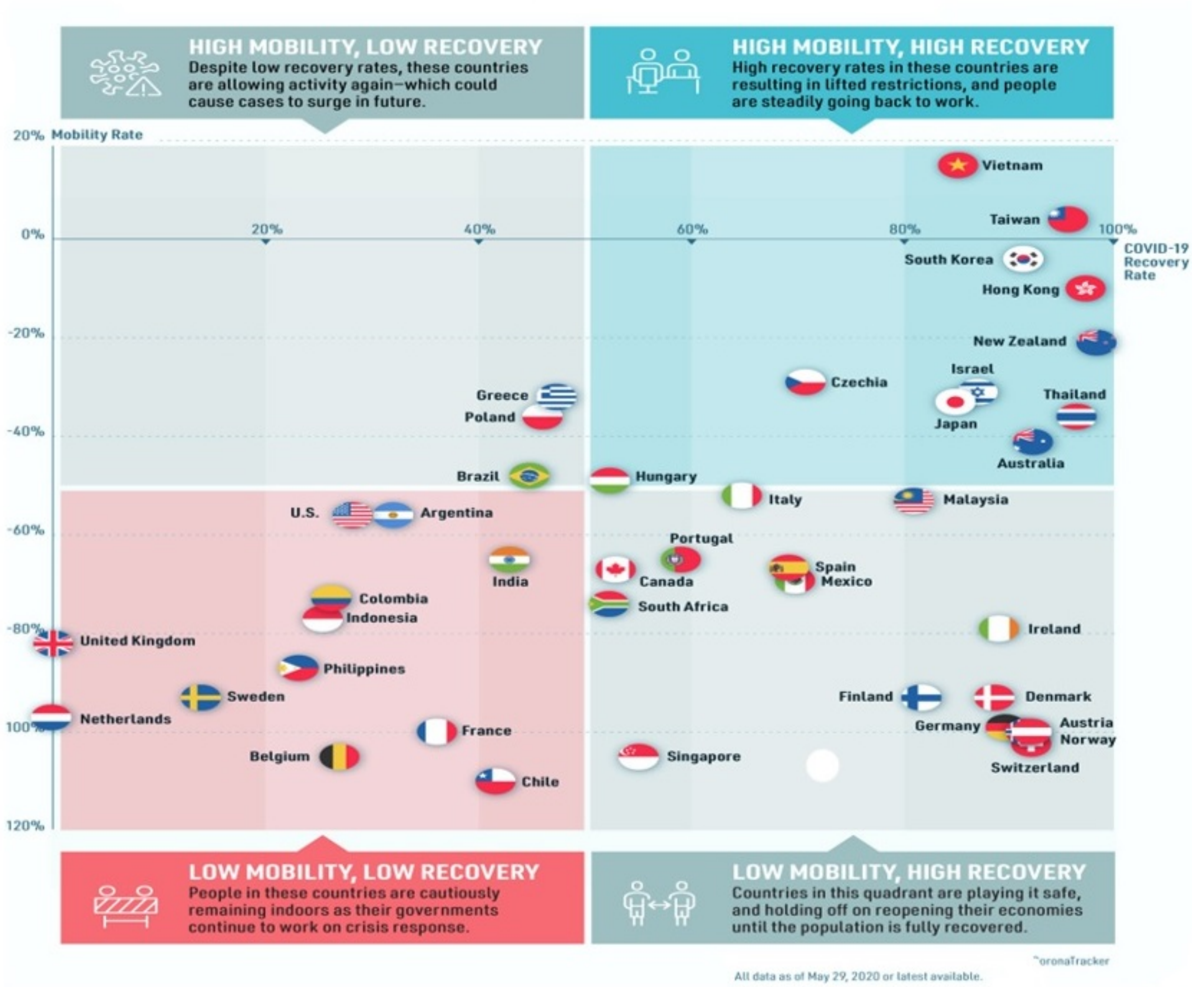

Figure 1. Mobility and Recovery - Countries Comparison

Figure 1 is adapted from a website which defines mobility as workplace mobility minus residential mobility, with the base line being zero, while the COVID recovery rate is defined as total recovered/total Covid-19 Cases. https://www.visualcapitalist.com/the-road-to-recovery-which-economies-are-reopening-covid-19/

The need to look at this from a world perspective has also been addressed in Puaschunder (2020) in which the role of technology, and in particular AI, has been argued to be very important in fighting infectious diseases. The author believes that countries with high internet connectivity and GDP are likely to lead on "AI-driven big data monitoring insights". This prophecy has yet to play out in the case of United States. The hindrance could be that the pandemic is inherently not only a challenge for science, but equally and perhaps more significantly, a challenge as a political socio-economic decision. Considering the scope of technology being very board, the selection of particular technology being used is a political and a subjective decision made in a country. There is no assurance, given that public health is a "public" decision, and that some technology can be more effective in speeding up mobility and recovery rates than others, that the most effective technology will be adopted.

An area where technology can definitely be applied is contract tracing, which is one of the Ts of the TTT used by many health authorities. Technology applications in contact tracing, which entails all types of contract tracing aim to improve efficiency in identifying suspects of virus infections, is extremely important for curbing the spread. Digital contact tracing is likely to improve efficiency over manual contact tracing significantly. However, as will be further argued in this paper, it is unlikely to be adopted quickly.

At the outset, no matter how sophisticated a technology is, there is always an element of human intervention that is necessary to enable a technology. As long as human decisions are present, there will always be some arbitrariness in implementing a technology, even if it is AI-driven. The minimum action is to turn a switch allowing connection to an energy source. The socio-economic angle of implementing a technology cannot be understated: Who is going to monitor the performance of the "agents" in implementing a technology? In other words, insofar as asymmetric information persists in human interactions, the economic problem of incentive-compatibility must be addressed.

Mitigation remedies as a matter of social engineering will not work if individuals do not find that they will benefit from participating in the fight against a contagious virus. The rational calculation for most individuals is that they will not be so unlucky to be infected; and thus, necessary precautions will not be voluntarily adopted unless the virus hit upon your own body. This phenomenon is most acutely revealed in the case of USA, where a significant population in that country still refrains from wearing masks and social distancing, despite rising statistics warning of a surge in infection rates. Likewise, a suspect uncovered in contact tracing is likely to first resort to self-healing, rather than voluntarily goes through the trouble of being tested; unless the person is doing it for the public good, or simply out of curiosity. Most people would prefer the virus being exterminated by someone else rather than they themselves.

The balance between individual liberty (freedom to interact and freedom to associate) and public safety is a matter of preference that varies between communities. Individual liberty is a concept very broad, but we have to recognize that traveling, as an integral part of many economic activities, is a bulk of what constitutes individual liberty. This is so not just for cross-border needs, but also for daily activities of most people commuting, many utilizing virus-transmission-prone public transportation which they cannot easily avoid. At the micro level, some communities may adopt a country's broad base policy of closing the doors too, i.e. no visitors, even though visitation is a matter of basic necessities. Social distancing indeed can be extremely costly for all types of activities, retails, recreations, neighborhood caring, etc., because mobility and close contacts with one another is essential to sustain any community, large or small. Shutting the doors is the most primitive way of dealing with the problem, but it may not be the smartest way of dealing with social distancing. Worse still, it does not address to the asymmetric information problem. It just avoids it.

It is mindboggling why in this digital age, we are still using the most primitive method of dealing with a spreading virus, reliving the Antonine plague of the Roman Empire. With evolving technology and looking forward, the real issue is whether we can utilize technology to provide a mobility guideline without giving up too much of privacy. In the case that we have to give up some degree of privacy, whether the privacy to yield is over-demanding. Mobility unavoidably will utilize some forms of public goods, as privacy in a public good environment can never be total. But first of all, we need to understand the journey of a virus to truly understand why there is a need for a holistic approach in fighting a common invisible enemy involving cooperation between the health system and the community. By understanding the dynamics of the virus spread, we can more acutely develop a strategy at the community level that is incentive-compatible for solving the asymmetric information of human interactions, which is the essence of the problem caused by an infectious virus.

The Traffic Lights of a Contagious Virus

Every virus (million kinds of them) has its journey on earth, sometimes going through an incubation period, and sometimes more active and more focused in certain regions of the world. When traveling on earth, a virus is transmitted from a source to 5 different platforms. The human platforms consist of 3 types—Asymptomatic (no symptoms), Clinical Symptomatic (proven by tests), Nonclinical Symptomatic (cured by self-healing, or some traditional methods such as lemon or ginger tea, sinus rinse, etc.). Nonhuman platforms consist of dead objects (different type of surfaces), and animals (furs, feathers, etc.). There may be other platforms, e.g. food, air, water, or very broadly, in terms of a geographical region. These are platforms that can either be easily controlled (e.g. not eating certain food), or impossible to control (e.g. in the atmosphere). Scientists still do not know for sure how a virus is born. All we know is that it is discovered in a geographic region.

The spread rate of a virus can be exponential, but through what platform? The spread rate is usually tracked within the health care system of a country through clinical tests. That is usually how the spread rate is calculated. Understanding the journey of a virus via other platforms can track the spread as a traveling map of the virus, and perhaps can also point out directions for collecting missing data. This understanding may suggest more focused ways of doing social distancing, surveillance, or quarantines.

A diagram below assumes a virus comes from the 1st case identified in the health system of a geographical region (community). The 5 different platforms to propagate the virus is symbolically described as a fork with 5 prongs, with the middle prong being an individual tested positive, a Red-light individual. Because there are other media to transmit the virus (via the other prongs of a virus attack), the virus could get out of the health system. Indeed, the 5-pronged attack list the logical possibilities at every successive stage of a virus propagation (not drawn to scale). The 5 platforms are drawn only for the 1st level of infiltration, with individuals and objects at that level being subscripted by 0. At the second level of infiltration, only the middle prong platform is highlighted, while other platforms are hidden from the diagram for simplicity of exposition.

As will be shown in the diagram and explained further, individuals being affected by the virus could be labelled by the traffic lights of Red, Yellow, and Green at each level of the transmission journey of the virus. Humans affected by a contagious virus could be Symptomatic (S) or Asymptomatic (A), both types can be indexed by the time stage of a spread, subscripted by 0, 1, etc. depending on the level of infiltration. A Red light is activated when the virus is caught by a clinical test. A Yellow light is activated when a virus is alerted by individuals themselves, and is usually coped with by traditional self-help methods, which may or may not resume their health back to normal. The Yellow light can turn to a Red light in successive stages when self-help is ineffective. In that case, the individual with the virus is turned Red, and will be counted in the system.

All Reds are counted within the system. All Greens and Yellows are counted outside of the system. Thus, looking at the spread of the virus in terms of this traveling map, the management of individuals outside the health system is as important as the management of those caught by the health system. The color Red denotes all activities and individuals in the health system. As one can see, there are many other activities and individuals outside of a health system.

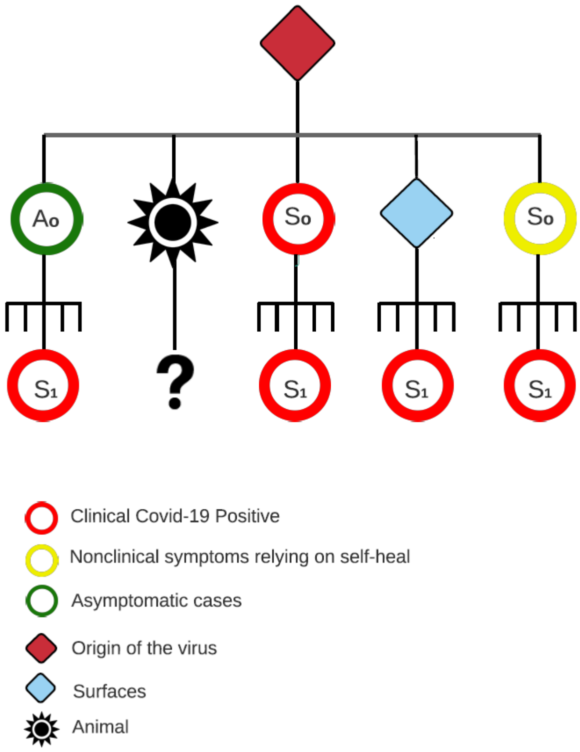

Figure 2. The 5-pronged Infiltration of Virus in a System

Figure 2 illustrates the travelling map of a virus in understanding the means and extent of a virus spread. Let's think through this process more carefully. The Green-light viruses, i.e. the asymptomatic cases, are the most problematic considering they are not detectable by the health system. The only way to limit its spread is by limiting its traveling, i.e. social distancing for 14 days. If within that 14 days, the light turns Yellow and then Red, the virus is thereby registered into the health system. If the Yellow light is switched on only for a short while and then turning to Green, the virus has existed only for a short time but conquered by the individual's antibodies, i.e. the virus dies or hibernates before the 14-day quarantine is over. Of course, there are people who turn Yellow for other ailment while they are actually Green.

Health systems in the world are spending most of their resources in managing the Red-light virus in the system. Effective slowing down of the virus spread may want to address to methods of managing the Green and the Yellow lights also. Some of the more successful cases have to rely on a government-community cooperation, e.g South Korea (Power 2020). Taiwan (Lanier and Wyle 2020), almost always relying on some degree of electronic contact tracing. However, digital contact tracing is not generally accepted as a voluntary opt-in without a great degree of community persuasion. Description of digital contact tracing across different countries can be found in many studies, e.g (Junn 2020). China's "health code" service resembles the traffic lights system described in previous paragraphs. Yet, there is a huge difference between the meaning of Red, Yellow, and Green in the China system and the one described in this paper. In China, Greens are given to healthy people with good physical mobility, while the traveling map in this section refers specifically to the asymptomatic. The Reds in the China system refers to "either a confirmed or a probable case [that] should be in mandatory quarantine", whereas the Red lights in this paper are clinically confirmed positive cases. Also, the codes assigned in China to an individual is not done voluntarily; instead, codes are assigned to individuals. Some users complained "about the lack of transparency over how codes are assigned and what data is being stored by Alipay and WeChat."

Digital Contact Tracing and why it might not work

Even though digital contact tracing is technically feasible, there is always a "soft" aspect relating to the use of digital device that makes it unpopular for voluntary participation. Already, we have seen many attempts on utilizing mobile phones for mobility tracking, e.g. (Marson et.al. 2020; Doffman 2020; Szklarski 2020). Google maps are being used to identify high density neighborhoods and high mobility hotspots, (Copeland 2020; Griffiths 2020; McLeod 2020). Yet, we are not seeing health systems in North America widely embracing digital contact tracing, even after the Google-Apple contact tracing app is announced for adoption (Albergotti 2020). Despite the best of intentions in most attempts to devise a contact tracing system, there remains many challenges. In the case of digital contact tracing, there has been much debate about privacy concerns relating to its mobile application. Several developers of such platform have repeatedly assured the public that individual's privacy is protected throughout the course of use. To a greater extent, companies such as Apple and Google have refused to give health authorities wider control over the types of information that the latter can retrieve from app users (Albergotti & Harwell 2020).

Aside from technical challenges in enabling cross-platform Bluetooth "chirps", the key to a digital contact tracing app entails the following procedure:

> "Phone owners would get involved by downloading an app that enables this system. After a positive diagnosis, a person would receive a QR code from a health official. By scanning the code through that app, that person can upload their log to the cloud. Anyone with the app could then initiate their phones to scan these logs. A notification, if there's a match, could tell a user how long they were near an infected person and the approximate distance." (Foy 2020)

One can imagine that a string of "soft" questions could be asked concerning how individuals will be using the app. First a person may not want to download the app because the individual does not trust the privacy features that are being promised. Second, even if the app is downloaded, the person might not have the phone or Bluetooth switched on while in a public place. Third, the app user might not want to visit a clinic for testing even if notified, because the person is asymptomatic and feels perfectly healthy.

An evaluation of various digital contact tracing apps used in different countries have been made in (Kleinman & Merkel 2020), noting the need to merge the numerous digital contract tracing methods. Regardless of the types of method used, the situation can get complicated if digital contact tracing, after having identified infected individuals, is then followed up by phone calls, tests, consultations, possibly tracing other leads. This requires contacting other people the infected individual knows too. The infected individual may not want to intrude into the privacy of the people he knows. In countries (communities) where cultural participatory instinct is high, and indeed a matter of responsibility, the soft components will not lead to a complete failure of a digital contact tracing application. The same cannot be assumed for an intrinsically individualistic society. For such society, an incentive-compatible solution must be designed to accompany a digital contact tracing technology.

Another limitation of a pure digital contact tracking app not working well is that there is a turn-around time between testing and receiving results from the tests. During the waiting time, the individual remains active in the community, which means the person could spread the virus during the waiting period. For high potency virus, even a short waiting time can cause a lot of additional infection to the community, especially if the person feels healthy and well (i.e. the asymptomatic cases of Green lights). According to a study, there is 80% of the COVID-19 positive cases that are asymptomatic. Other studies reported a lower percentage.

An Incentive-Compatible participatory Solution

We propose for a community app that utilizes digital real time identification of hot-spots and safe-spots, based on voluntary participation of opt-in individuals. We ask individuals, on their own accord, label themselves as Green, Yellow and Red lights. This proposed app does not involve Bluetooth technology, but would require a common display across different operating systems. The goal is to make the dashboard of a community participation to be easily recognizable. The soft component of this app must be easy to use and nonintrusive. The opt-in questionnaire should be at a minimum, perhaps requiring the person to declare the light color initially when they opt-in, before symptoms are worsen. This implies that initial participants being likely to be either Green or Yellow.

Whether the Red lights are to be included initially depends on the persuasive skill of the staff in a health system, but it need not depends on a health system for the app to initiate. It poses no legal liability to a health system, and it does not entail retrieving the health information data of the infected individuals into the opt-in app. Indeed, if the program opt-in can be made incentive-compatible, and if a virus spread is real, some of the Green and the Yellow lights in the system will turn Red without health system involvement. The display on the dashboard does not need to be entirely accurate but serves only to show a rough distribution of the traffic light colors within a geographical area. If successfully implemented, the number of Reds in the app would coincides with the number of Reds that are registered in the health system. The crucial question to ask is: How to make the community-based counting system converge with the health system statistics. The answer lies on designing an appropriate incentive-compatible participatory solution.

To be sure, there are already efforts being made by use of color lights in different countries. They are similar and yet fundamentally different as commented in the previous section about the Health Service Code in China. An interactive map and dashboard developed by Harvard Global Health Institute/Microsoft AI, for example, reported regions in the USA as Green, Yellow, Orange, and Red in real time. Risk levels are calculated based on daily cases per 100,000 population (7 day rolling average). https://globalepidemics.org/ The site uses data from the health system; but as we have argued in this paper, there is a need to monitor safety outside the health system. As far as proactively managing the Green and the Yellow in our framework, the dashboard only requires individuals who have opted-in to declare their colors. These voluntary participants will not be contacted by health authorities or the app, which is significantly different from the Bluetooth-driven contact tracing technology that many are developing, as described in the previous section.

A dashboard of the above-mentioned type is useful even if it is not entirely accurate at the initial stage of its implementation. If enough percentage of population has opted-in, existing residents as well as incoming visitors to an area can avoid cluster areas of Reds and Yellows, i.e. avoid to being close to viruses that are probably most potent. To be sure, this does not replace social distancing as a preventive measure. It is an additional layer that if one is taking necessary precautions, one can more actively control the risk level directly. Any rearrangement of risk level perceived by choosing location will allow people more open to interact and do business with people. That is the crux of the matter: how to get people back to their normal life, without being overly burden by the threat of asymmetric information.

It is true that there are soft parts of this participation scheme similar to that discussed in the above section on contact tracing, but the requirement is minimal, particularly if one recognizes that the reduction in asymmetric information to the public will be immense. It is worth emphasizing that there is no need for the individual to reveal personal identify except for their localities in the map. The degree of participation is similar to what Google is using for tracking mobility. The only layer added is a self-declaration of Green, Yellow, or Red, noting that only the Reds are registered into the health system of a geographical boundary.

It is also possible that the described app could be subject to the same cybersecurity risks, the same vulnerability of AI robot intrusion, the same footprints of cookies and digital marketing techniques that a new core of professionals are now trained to do. However, we do not see the targeting of the said platform to be particularly lucrative for hackers to prey on. The interactive input required by the program participants are limited only to the declaration of the traffic light colors they represent. The ill-incentive of terrorizing and sabotaging the system does not appear high. Indeed, the motivation would lean towards the good side of human nature than the worse side, all striving to achieve better public safety, a common good, i.e. like not littering, not spitting, no foul language in public space, etc. These are the basic modern civility that residents and visitors most likely are already practicing.

Last but not least, and perhaps the most important aspect of this community-based solution is we are proposing is to make community participation to be incentive-compatible whereby a *bonus* (monetary compensation) will be given to the Red-lights who are clinically proven to be positive. The resource funding needed to administer this scheme is affirmatively lower than the manual contact tracing expenses that many health authorities are currently using. The bonus should be high enough to compensate for the inconvenience of checking in to the health system for tests and for the loses in days of work if found positive. However, it should not be overly high to encourage a deliberate exposure to the virus simply for purpose of winning the bonus, a jackpot. Conceptually, an appropriately set bonus scheme will incentivize individuals in two ways: It will make (1) individuals more likely to opt in to the program, and (2) individuals will be more likely to go for tests when they feel sick (i.e.Yellow), rather than practicing self-heal and in the process spreading out more virus.

Our proposed solution for voluntary community participation obviously has other aspects of implementation that need to be addressed, e.g. selecting an appropriate partner for marketing the program, the funding of the bonus, etc. However, we see this being conceptually different from either TTT, manual contact tracing, and digital contact tracing. Therefore, it is a solution that is worth considering as a component of a holistic approach to curb a pandemic. Furthermore, as a managerial economic problem, a community based-solution does not entail the same technical investment of AI/ML, which can be costly, and bureaucratically difficult to implement because of privacy considerations. The technology requirement of the community-based solution is minimal. It is more of a socio-economic challenge. A challenge that we believe entails relatively low monetary investment, community-specific and thus does not require universally being applied to all communities in the world. Most important of all, it can be implemented entirely voluntarily as a community decision.

Conclusions

The economy cannot be forever held hostage by a virus, even though Covid-19 is uniquely different. Closing any type of country borders, be it peripheral or internal, curtails a country's economic growth and development. Fundamentally, it disrupts human desire, and the *need* to move from one location to another. As globalization and interstate economic activities become increasingly inherent, border-crossing has evolved to an *essential* need for many businesses and individuals. Hence, focusing on supply chain traffic by allowing only "essential" crossing is unsustainable. This makes it all the more crucial to have in place constructive means of curbing the viral spread, rather than restraining necessary movements by sealing-off national and regional boundaries.

This paper argues that a community-based solution outside of health system administration can be designed to fight the war on a spreading virus holistically, rather than from within the health system only. This solution must find ways for the community to voluntarily opt-in to help fight the virus. If participants' efforts can be made incentive-compatible without compromising on individual privacy, a larger percentage of opt-in volunteers should be expected, which will lead to the success of the program.

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